Mechanism Analysis

Creating Motion!

Elements of a Mechanism Analysis

1. Scenario
2. Rigid Bodies
3. Markers
4. Joints
5. Input Motions/Forces

1. Scenario

- Scenarios contain all the information of a single mechanism motion analysis.
- To perform a mechanism analysis select the “Motion” application.
- To create a new scenario:
  - move the mouse over the assembly in the “Scenario Navigator.”
  - Press the RMB
  - Select “New Scenario.”

2. Rigid Bodies

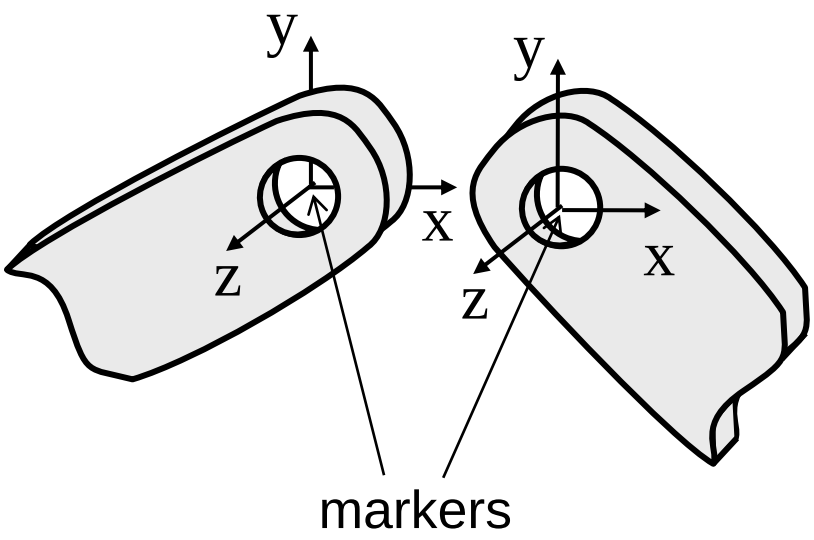
- Rigid bodies (or links) are bodies that experience motion.
- Each rigid body adds 6 degrees-of-freedom to the system

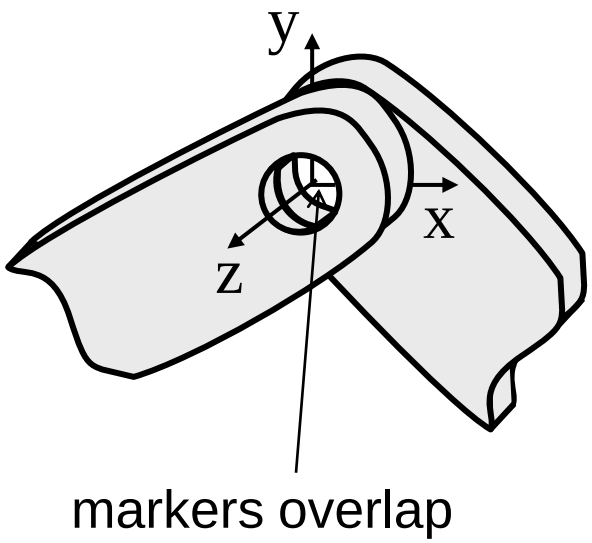
To create a rigid body

1. Press 
2. Pick assembly components (or an object) to create a rigid body with that geometry.

3. Markers

- Markers specify the position and orientation of joints on a rigid body.





Markers

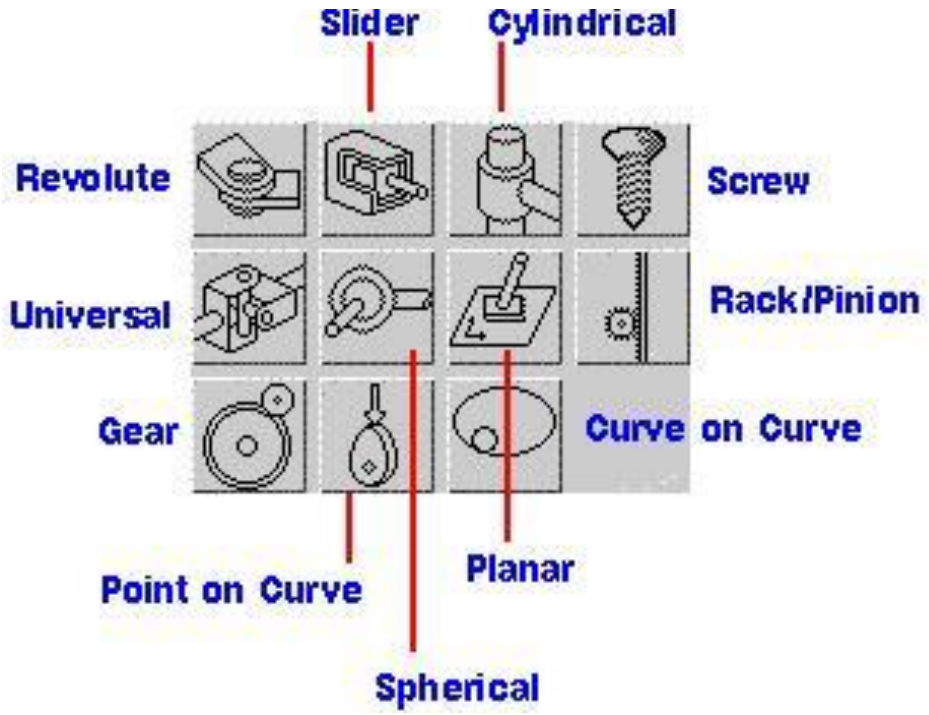
- There are always two markers per joint – one on each body.
- Created automatically when creating joints.
- Make sure that the *Z* axes of both markers of a joint are in the same direction.

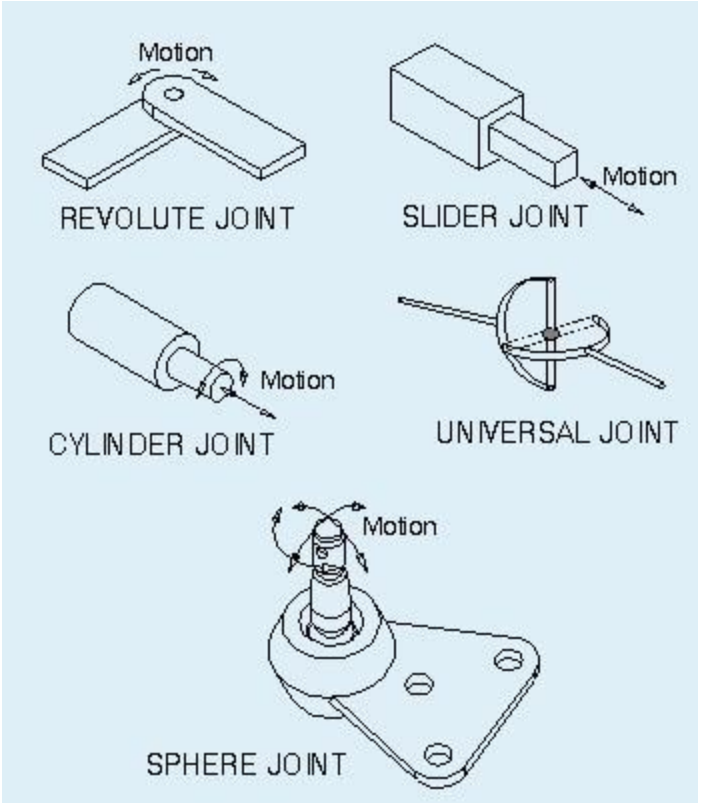
Snapping

- If two joined links are not lined up in the assembly you will need to use “Snap links” when creating joints.
- Normally you only need to specify the marker location on one link. With “Snap links” checked, you will need to pick marker locations on both links.

4. Joints

- Joints restrain degrees-of-freedom.
- Types of Joints:





Figures from Unigraphics on-line documentation.

Creating Joints

1. Press  . Pick type of joint.
2. Pick first link.
3. Pick joint location. Specify “Point” and “Vector.”
4. Pick second link or press OK for ground.

- Joints are drawn in the graphics window. If they don’t show the correct position or orientation, you will need to re-specify the origin and orientation.

The Gruebler Count

- The number/type of joints required is determined by the "Gruebler count":

$$G = \#links \times 6 - \#joint\_constraints - \#input\_motions$$

- If:
  - $G < 0$: over-constrained mechanism – kinematic analysis
  - $G = 0$: well-constrained mechanism – kinematic analysis
  - $G > 0$: under-constrained mechanism – dynamic analysis
- In kinematic analysis, motion is totally controlled by input motions. Any input forces are counter-acted by reactions at motion input.
- In dynamic analysis, motion is controlled by forces and masses of links.

Creating Joints

Joint	#Constraints
Revolute	5
Slider	5
Cylinder	4
Screw	1
Planar	3
Sphere	3
Gear	1
Rack/Pinion	1
Point/Curve	2
Curve/Curve	2
Universal	4
(Motion)	1

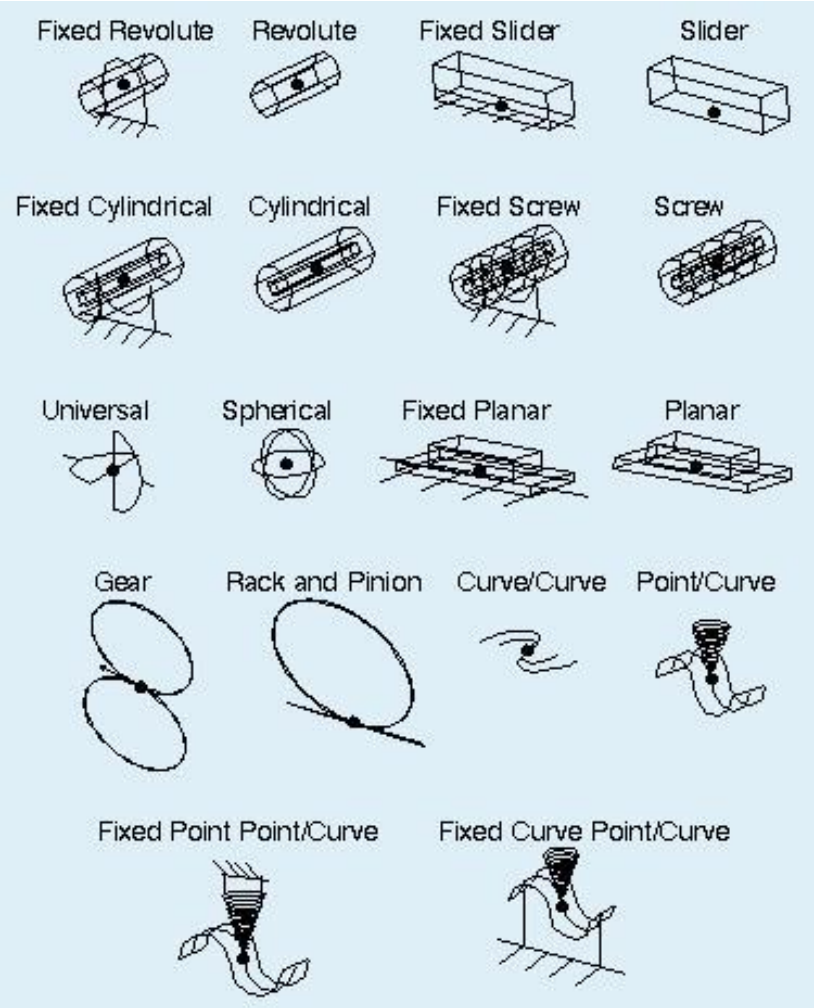


Figure from Unigraphics on-line documentation.

5. Motion/Force Input

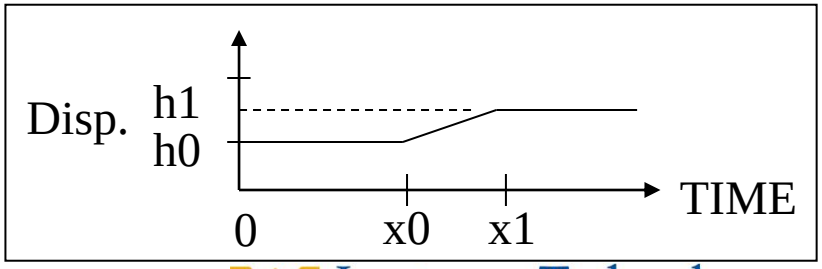
- Motion input
  - in NX motions are input with joints
  - specifies **second link** with respect to **first link**
  - "**Constant Driver**" motion follows:

    $x(TIME) = Displacement + Velocity \times TIME + \frac{1}{2} Acceleration \times TIME^2$

    where $x(TIME)$ is the angular or lateral displacement.
  - "**General**" motion driver allows arbitrary expressions to control the displacement. A useful Adams function is:

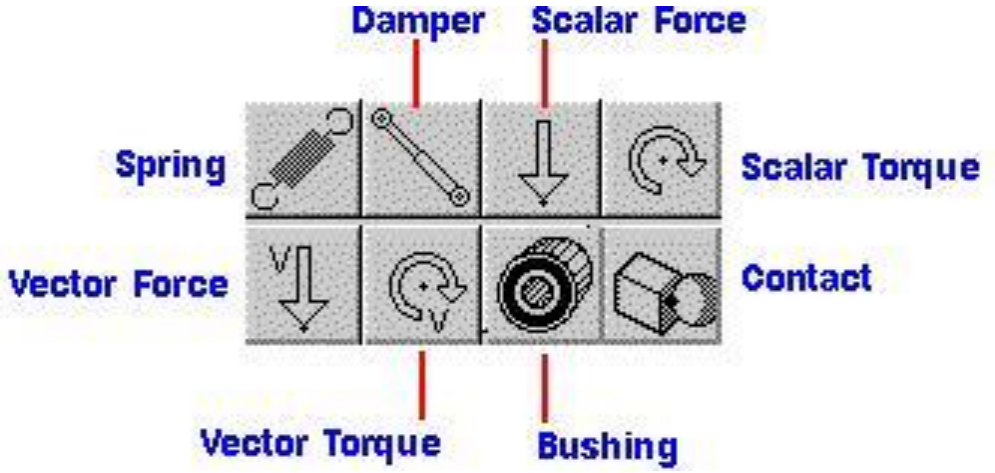
    STEP(x, x0, h0, x1, h1).

    E.g., STEP(TIME, 0.5, 1., 0.75, 1.5)



Motion/Force Input

- Force input
  - types of forces:



Remember that:

- In a **KINEMATIC** analysis, the motion is **controlled by the input motions**. The input forces simply allow you to measure reactions.
- In a **DYNAMIC** analysis, the motion is **determined by the input forces**, link mass properties, and joint locations.

Figure from Unigraphics on-line documentation.

Creating Graphs

Graphs can be created to plot:

- Displacement, velocity and/or acceleration as function of time step.
- Reaction forces and/or moments as a function of time step.

- Lateral or angular quantity.
- Magnitude or X, Y, Z components.

Interference Checking

NX provides three types of geometric analysis as the motion proceeds:

- Solid body interference
- Clearance distance infringement
- Motion tracing

Motion File Management

NX Motion automatically uses a “master model” approach to manage analysis files. The design (assembly) part is the master part which drives the analysis.

- When you create a new scenario, NX:
  - creates a new assembly part file with scenario name,
  - adds the design part as a component of scenario.
- This allows someone to do the mechanism analysis without write access to the design.

Motion File Management